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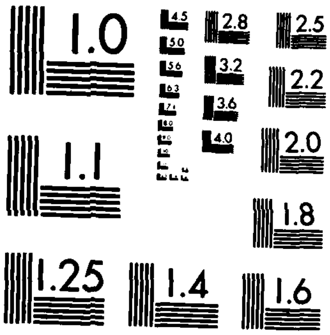

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PRESSURE ALTITUDE TESTS OF THE ARMY AN/MSQ-114 CONTROL TERMINAL

Judy C. Bergmann
Calspan Field Services, Inc.

December 1982
Final Report for Period 27 August 1982 - 27 October 1982

Approved for public release; distribution unlimited.

ARNOLD ENGINEERING DEVELOPMENT CENTER
ARNOLD AIR FORCE STATION, TENNESSEE
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

APPROVAL STATEMENT

This report has been reviewed and approved.

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FOR THE COMMANDER

JOHN M. RAMPY, Director
Aerospace Flight Dynamics Testing
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The Army AN/MSQ-114 Control Terminal was tested to determine the effects of 40,000 ft and 10,000 ft pressure altitudes on the transportability and operability, respectively, of the electronic equipment inside the terminal. During the operational test phase (10,000 ft) of the first tunnel entry, a problem developed with the electronic equipment and testing was terminated. The equipment was subsequently modified and tested successfully during a second entry.

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ILLUSTRATIONS

TABLES

NOMENCLATURE

CBOX1,2	Constant boxes 1,2
DELPI	Primary input deletion and selection code
DH/DT	Pressure altitude change rate, ft/min
DP	Differential pressure, PT-PC, psf
DPT/DT	Tunnel total pressure change rate, psf/min
DTDPS	Difference between test section static and dewpoint temperatures, °F
H	Pressure altitude, ft
M	Free-stream Mach number
MODE	Program data mode
P	Tunnel static pressure, psfa
PC	Tunnel plenum pressure, psfa
PN	Test point number (a single record of all test parameters)
PT	Tunnel total pressure, psfa
PTVi-j	Van total pressure j in room i, psfa
Q	Free-stream dynamic pressure, psf
REX10-6	Free-stream unit Reynolds number x 10^{-6}, ft^{-1}
RUN	Run number (a data subset containing variations of only one independent parameter)
SET	Constant set number
SHX10+3	Tunnel specific humidity x 10^3, lb H_2O/lb dry air
SHV*10+3	Van specific humidity x 10^3, lb H_2O/lb dry air
TDP	Tunnel dewpoint, °F
TDPV	Van dewpoint, °F
TIME/POINT	Time between completion of one data point and initiation of another, sec
TPR	Tunnel pressure ratio

TT	Tunnel total temperature, °F
TTR	Tunnel total temperature, °R
TTVi-j	Van temperature j in room i, °F
UX	Uncertainty of measurement of a given parameter, X
WA	Wall angle
WINDOFF	Windoff run/point used

1.0 INTRODUCTION

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), under Program Element 921C07, Control Number 9C07, at the request of the U. S. Army Satellite Communications Agency (USASATCOMA). The USASATCOMA project manager was Mr. Ken Masterman-Smith and the USASATCOMA project engineer was Mr. Michael Bukarica. The results were obtained by Calspan Field Services, Inc./AEDC Division, operating contractor for the Aerospace Flight Dynamics testing effort at the AEDC, AFSC, Arnold Air Force Station, Tennessee. The tests were conducted in the Propulsion Wind Tunnel (16T) in the Propulsion Wind Tunnel Facility (PWT) during the period from August 27, 1982 through October 27, 1982, under AEDC Project Number C750PG (Calspan Project Number P41G-1F), PWT Test Numbers TF635 (August 27-September 1) and TF643 (October 22-27).

The objective of the tests was to determine the effects of 40,000 ft and 10,000 ft pressure altitudes on the transportability and operability, respectively, of the electronic equipment inside the Army Control Terminal (van).

The van was tested at 40,000 ft and 10,000 ft altitudes, at zero Mach number. There were two entries in Tunnel 16T.

The purpose of this report is to document the test and to describe the test parameters. The report provides information to permit use of the data but does not include any data analysis, which is beyond the scope of this report.

The final data from this test have been transmitted to U.S. Army Satellite Communications Agency. Requests for copies of this data should be addressed to USASATCOMA/DRCPM-SC-9B, Ft. Monmouth, NJ 07703. A microfilm copy of the final data is on file at the AEDC.

2.0 APPARATUS

2.1 TEST FACILITY

The AEDC Propulsion Wind Tunnel (16T) is a variable density, continuous-flow tunnel capable of being operated at Mach numbers from 0.2 to 1.5 and stagnation pressures from 120 to 4000 psfa. The maximum attainable Mach number can vary slightly depending upon the tunnel pressure ratio requirements with a particular test installation. The maximum stagnation pressure attainable is a function of Mach number and available electrical power. The tunnel stagnation temperatures can be varied from about 80 to 160°F depending upon the cooling water temperature. The

tunnel is equipped with a scavenging system which removes combustion products when testing with rocket motors or turbo-engines. The test section is 16 ft square by 40 ft long and enclosed by 60-deg inclined-hole perforated walls of six-percent porosity. The general arrangement of the test section and the test article location is shown in Fig. 1. Additional information about the tunnel, its capabilities, and operating characteristics is presented in Ref. 1.

2.2 TEST ARTICLE

The test article was a semi-trailer, 34 ft long by 11 ft high by 8.4 ft wide (Fig. 2). Electronic equipment inside the van consisted of satellite monitoring and communications equipment. The van was divided into three rooms: room 1, with the power line entrance, not environmentally controlled; room 2, with most equipment, air-conditioned; and room 3, with office space and visual monitoring equipment, also air-conditioned.

2.3 INSTRUMENTATION

Six internal van pressures were measured, with two pressures in each room. Copper-constantan thermocouples were used to measure temperatures inside the van and near critical equipment, with one thermocouple in room 1, six in room 2, and three in in room 3. A hygrometer was used to measure the dewpoint inside the van during the first entry. Figure 3 shows the approximate location of the instrumentation.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS AND PROCEDURES

During the tests, Tunnel 16T was used as an altitude chamber (no temperature simulation). The test requirements consisted of a one-hour soak at 40,000 ft with the equipment in the transport mode (packed in specially designed shipping cases pressurized with dry nitrogen) followed by a one-hour soak time and operating tests at 10,000 ft with the equipment in the operate mode. A ten-hour soak at 40,000 ft altitude with dry air circulation was to be completed prior to the start of actual equipment testing in an attempt to evaporate moisture accumulated beneath the flooring in the van. Following completion of the final altitude soak, additional verification tests were to be performed by User personnel. The User specified that the maximum altitude change rate not exceed ±2000 ft/min.

During the first entry, testing followed the proposed schedule until the 10,000 ft, one-hour soak started. Within a few minutes after reaching 10,000 ft, an operating failure of the van's equipment was observed. The tunnel was returned to

atmosphere and the failed equipment replaced with spares. A second attempt at 10,000 ft requirement was made and the equipment failed again. After another return to atmosphere, this equipment was bypassed and the operation of the remaining equipment verified after a one-hour soak time at 10,000 ft.

The failure necessitated a second entry of the control terminal after the equipment had been modified. This entry also consisted of a one-hour soak time at 40,000 ft of the van in the transport mode, followed by a one-hour soak time at 10,000 ft in the operate mode with subsequent operating tests. During this entry, all equipment functioned correctly.

Tunnel operating personnel held actual altitude change rates to approximately ±1500 ft/min. Approximate altitude-time profiles for both entries are shown in Fig. 4. A summary of the configurations and test conditions is presented in Table 1.

All steady-state measurements were sequentially recorded by the facility on-line computer system, which reduced the data to engineering units, further processed the data to obtain the required model parameters, tabulated the data in the Tunnel 16T control room, recorded the data on magnetic tape, and transmitted the data to the AEDC central computer file. The data stored in the central computer file were generally available for plotting and analysis on the PWT Interactive Graphics System within 30 seconds after data acquisition (*see Fig.* 5). The immediate availability of the tabulated and plotted data permitted continual on-line monitoring of the test results.

3.2 UNCERTAINTY OF MEASUREMENTS

Uncertainties (combinations of systematic and random errors) of the basic tunnel parameters were estimated from repeat calibrations of the instrumentation. Uncertainties in the instrumentation systems were estimated from repeat calibration of the systems against secondary standards whose uncertainties are traceable to the National Bureau of Standards calibration equipment. The tunnel parameter and instrument uncertainties, for a 95-percent confidence level, are combined using the Taylor series method of error propagation described in Ref. 2 to determine the uncertainties of the reduced parameters shown in Table 2.

4.0 DATA PACKAGE PRESENTATION

The data package contained: 1) tabulated on-line data, 2) test article installation photographs, 3) video tapes, and 4) appropriate test logs for identification of test runs, test conditions, and test article configurations.

A copy of this Test Summary Report accompanied the data package. An example of the tabulated summary data is shown in Table 3.

REFERENCES

1. Test Facilities Handbook (Eleventh Edition). "Propulsion Wind Tunnel Facility, Vol. 4." Arnold Engineering Development Center, April 1981.

2. Abernethy, R. B. and Thompson, J. W., Jr. "Handbook - Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5 (AD755356), February 1973.

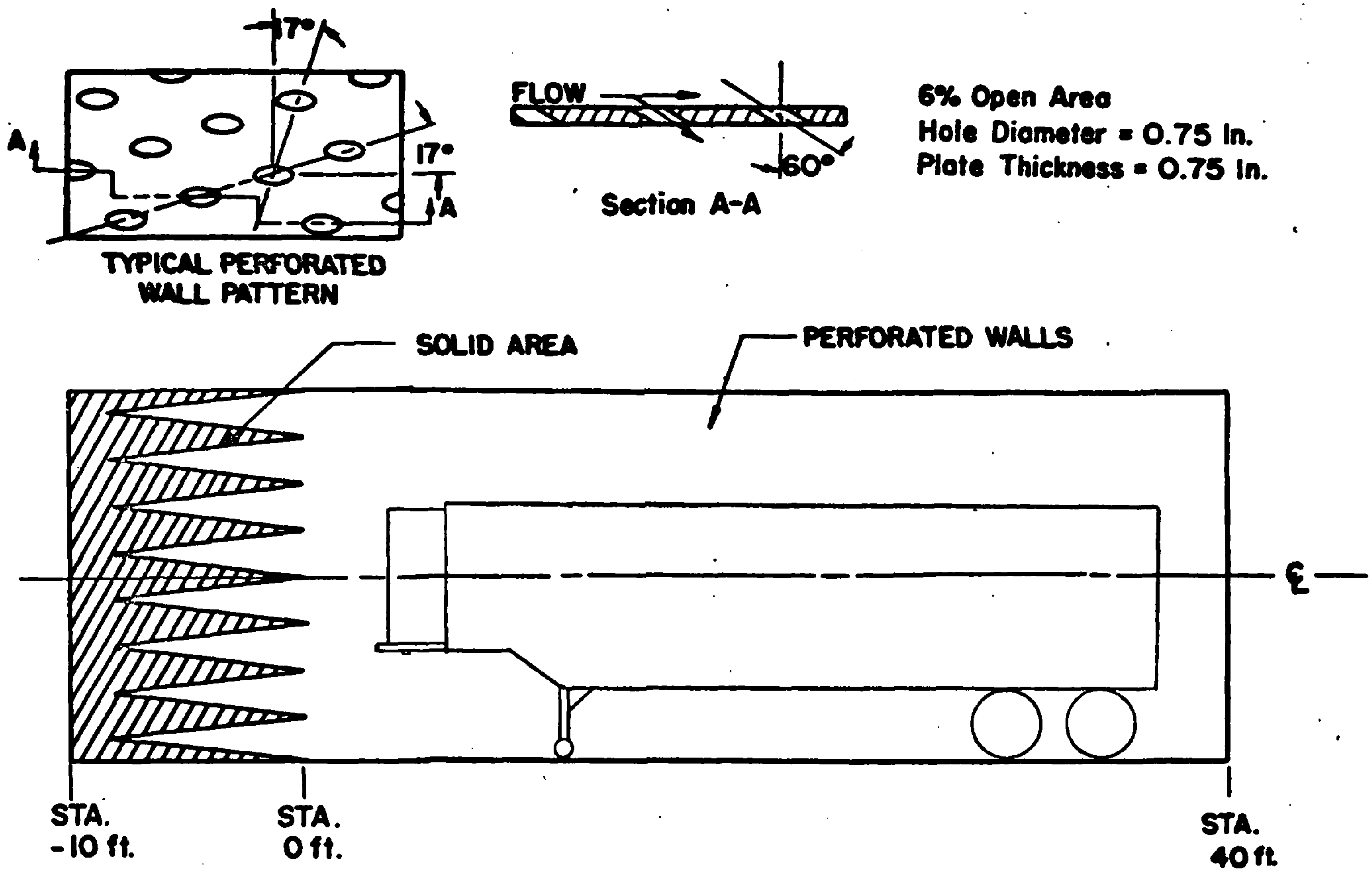


Figure 1. Test Article Location in Tu[illegible] 16T.

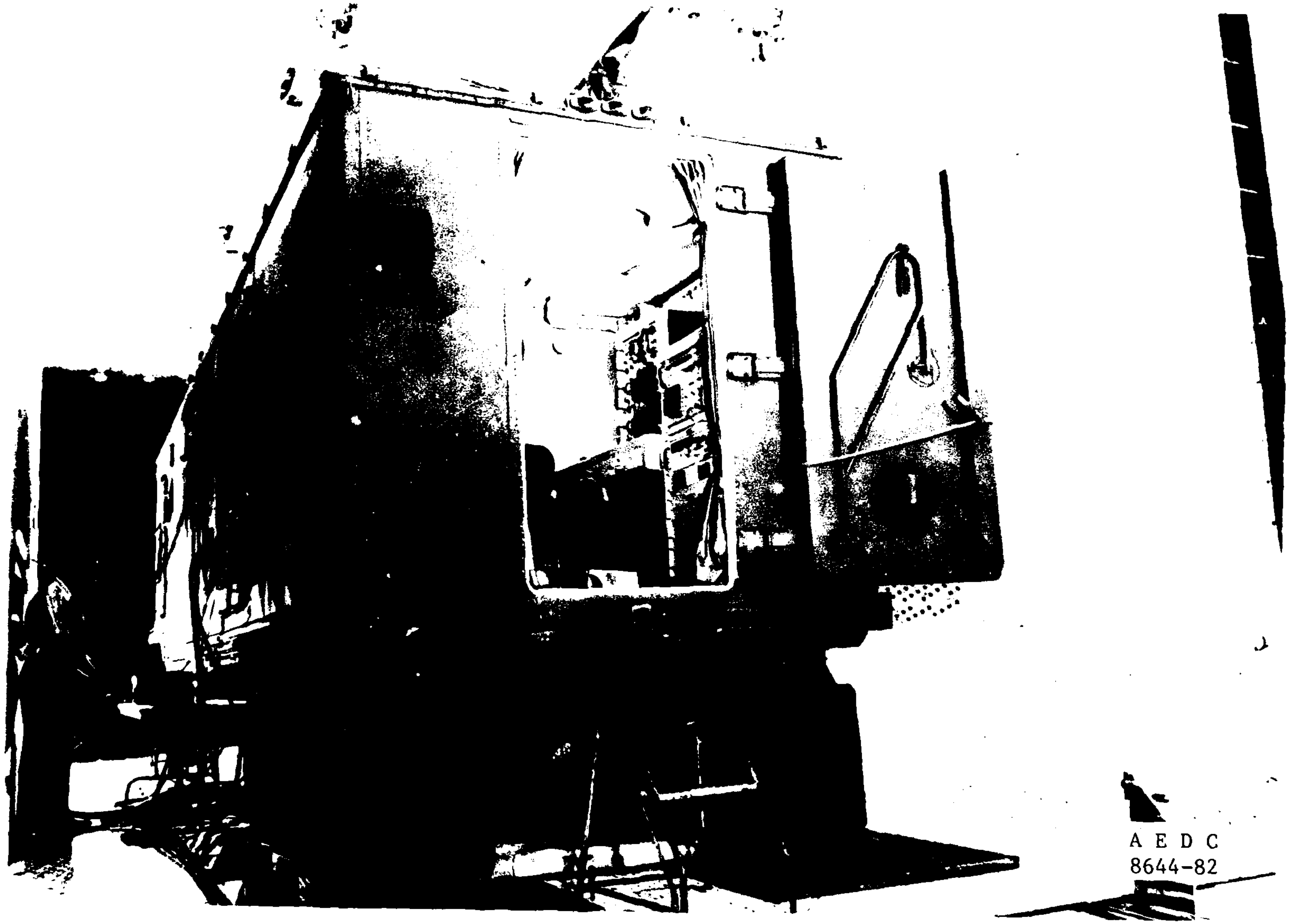
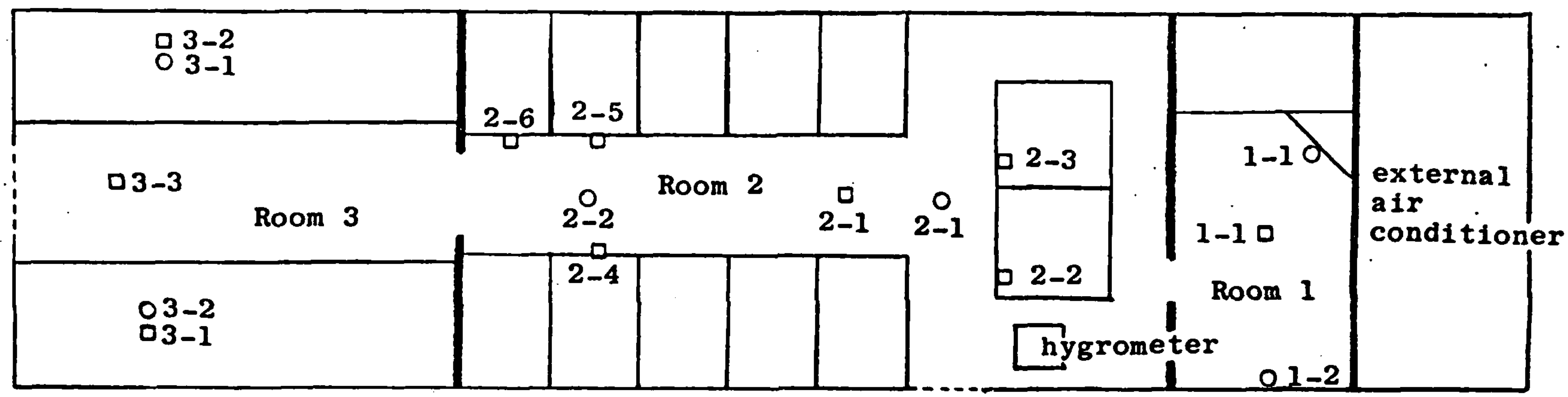


Figure 2. Test Article Installation in Tunnel 16T

Figure 3. Location of Instrumentation

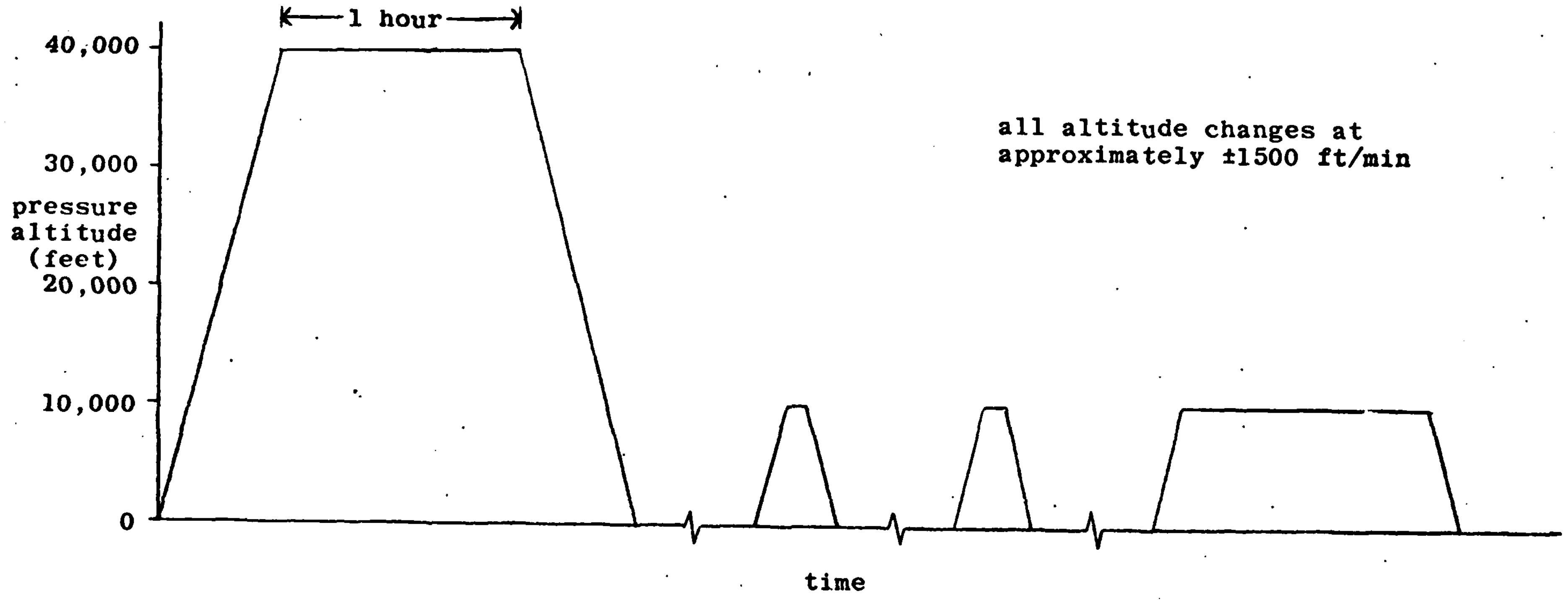


O Pressure line
□ Thermocouple

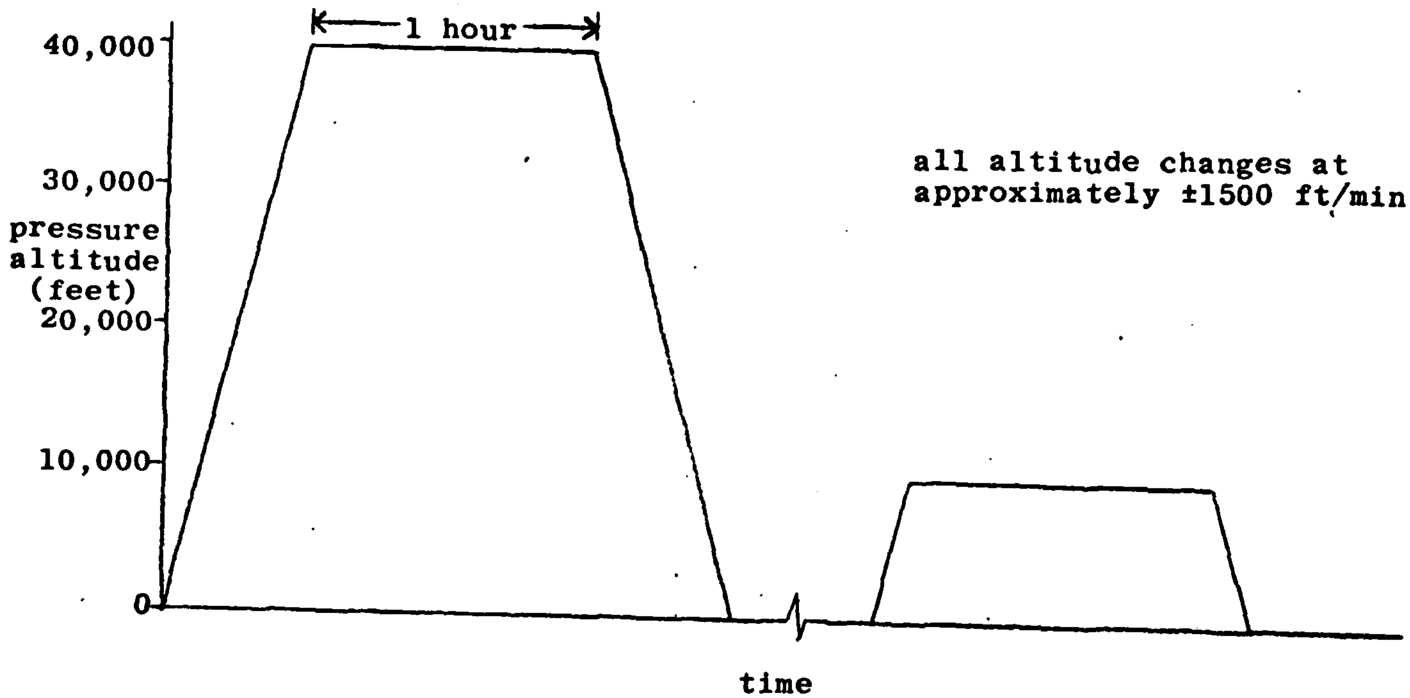
Drawing not to scale

Pressure lines
1-1 center of side wall
1-2 center of side wall
2-1 bottom of ceiling-mounted air conditioner duct
2-2 bottom of ceiling-mounted air conditioner duct
3-1 ceiling
3-2 ceiling

Thermocouples
1-1 center of ceiling
2-1 bottom of air conditioner duct
2-2 inside top of equipment rack
2-3 inside top of equipment rack
2-4 near top front of equipment rack
2-5 near top front of equipment rack
2-6 near top front of equipment rack
3-1 ceiling
3-2 ceiling
3-3 ceiling, in exhaust draft of air conditioner duct



a. First Entry
Figure 4. Altitude-Time Profiles



b. Second Entry
Figure 4. Concluded

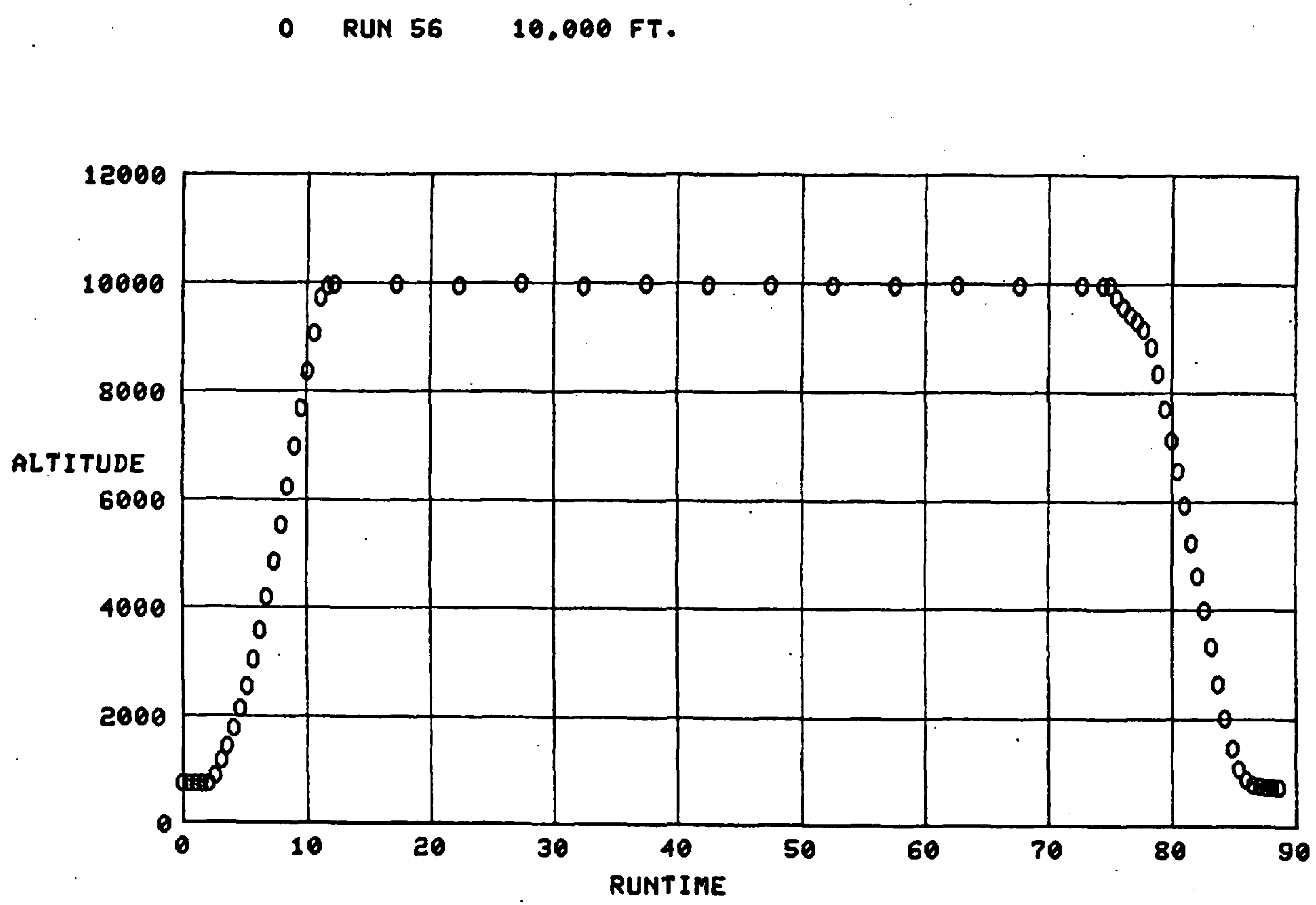


Figure 5. Interactive Graphics Plot--Typical Altitude-Time Profile

Table 1. Summary of Test Article Configurations and Test Conditions

Run	Configuration	Test Conditions	Entry
12 13,14,15 16,17	Transport (drying)	Pump down to 40,000 ft. Hold at 40,000 ft. Return to local level.	First
19 20	Transport (testing)	Hold at 40,000ft. Return to local level.	
24 25 26	Operate	Pump down to 10,000 ft. Hold at 10,000 ft. Return to local level.	
28 29 30	Operate	Pump down to 10,000 ft. Hold at 10,000 ft. Return to local level.	
35 36 37	Operate	Pump down to 10,000 ft, Hold at 10,000 ft. Return to local level.	
52	Transport	Pump down to 40,000 ft, hold, and return to local level.	Second
56	Operate	Pump down to 40,000 ft, hold, and return to local level.	

Table 2. Data Uncertainties

H(ft)	PT (psfa)	±UH(ft)	±UPT(psf)
876	2050	21	1.55
10,000	1455	26	1.48
40,000	394	69	1.35

PTVi-j (psfa)	±UPTVi-j (psf)
394	2.03
500	2.20
1000	3.00
1455	3.73
2050	4.68

±UTTVi-j 2°F

±UTDPV 2°F

DATE 19-NOV-82 PROJECT NO P43G-1F
ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
PROPULSION WIND TUNNEL
ARNOLD AIR FORCE STATION, TENNESSEE

TRANSONIC 16T

RUN	EN	PROJECT	TEST	DATE	DAY HR MIN SEC	MODE	DELPI	PROD DATE	WINDOFF	SET	CAPT
36	3	P43G-1F	TF-635	9/ 1/82	244: 0:20: 3	49/ 0	769	19-NOV-82	34/ 4	30	1.

M	PT	P	Q	REX10-6	TT	TTH	H	PC	DP	KA	TPR	SHX10+3	TCP	DTDPS
.000	1454.5	1454.5	1.0	-0.010	78.1	537.8	10002.	1454.5	0.0	0.00	0.000	6.416	35.8	42.3

K15	DDAS:A	SAMPRA	DPS:PSSCI	PSSLOP	PSTOUT	PSTREQ	PSCHMS	PSVMS	PSPCHS	PSNCNS	PSMPHC	PSMPDR	A	SAMPRA	SVET	SVPS
.0	0.899	50.	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SVPD	SVSLOP	SVTOUT	SVMVLV	SVMPRT	SVMPRV	SVIAC	ASV	SAMRSV
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CONFIGURATION	TIME/PT	CBOX1	CBOX2
10,000 FT-TESTING	300	3	300

H	DH/DT	PT	DPT/DT	TDPV	SHV*10+3
10002.	-3.	1454.5	0.1	42.0	8.215

PTV1-1	PTV1-2	PTV2-1	PTV2-2	PTV3-1	PTV3-2
1455.0	1455.0	1454.0	1454.0	1454.0	1454.5

TTV1-1	TTV2-1	TTV2-2	TTV2-3	TTV2-4	TTV2-5	TTV2-6	TTV3-1	TTV3-2	TTV3-3	TTVS
75.0	79.9	90.0	87.5	72.7	67.8	73.7	76.4	76.4	62.2	150.0

Table 3. Sample Tabulated Data Printout

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